MERRIMACK RIVER BASIN

NASHUA, NEW HAMPSHIRE

SUPPLY POND DAM

NH 00123

NHWRB 165.06

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

FEBRUARY 1979

UNCLASSIFIED

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a 550 ft. long, 28 ft. high earthfill embankment with a gravity stone masonry core wall extending an undetermined length onto the embankment. Modifications were made to the dam consisting of the construction of the gravity masonry spillway and the extension of the gravity stone masonry dam into the left bank. It is small in size with a significant hazard potential. The dam is in fair conditionat the present time, but requires detailed investigations of the upstream face of all masonry structures.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

MAY 29 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Supply Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Pennichuck Water Works, 11 High Street, Nashua, New Hampshire 03060.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

SUPPLY POND DAM
NH 00123

MERRIMACK RIVER BASIN
NASHUA, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.: NH 00123
NHWRB No.: 165.06
Name of Dam: SUPPLY POND DAM
City: Nashua
County and State: Hillsborough County, New Hampshire
Stream: Pennichuck Brook
Date of Inspection: October 31, 1978

BRIEF ASSESSMENT

Supply Pond Dam is a 550 foot long, 28 foot high earthfill embankment with a gravity stone masonry core wall extending an undetermined length into the embankment. The dam also includes a 30 foot gravity type cemented stone masonry spillway, a former pump station (No. 1) now used for equipment storage, a wood framed gate house located immediately upstream of the former pump station, and a pump station (No. 4) located approximately 15 feet downstream from the left side retaining wall of the dam.

The outlet works for the dam include two 3 foot by 4.2 foot gates and a 30 inch diameter penstock through the dam running to the pump station located downstream and to the left of the spillway. Additional flow regulation is provided by the operation of Harris Pond just upstream of Supply Pond. A 72 inch diameter penstock from Harris Pond flows to the operating pump house.

The dam is owned by the Pennichuck Water Works. Available records indicate that the dam was built in 1870, with the two pump stations probably being constructed at that time. At some later date, modifications were made to the dam consisting of the construction of the gravity masonry spillway and the extension of the gravity stone masonry dam into the left bank.

The dam, which lies on a tributary to the Merrimack River, is used for water supply. The drainage area for the structure is 25.4 square miles. The dam's maximum impoundment of 245 acre-feet and height of less than 40 feet, place this dam in the SMALL size category. In the event of failure, the significant property damage and the remote possibility of loss of life warrant a SIGNIFICANT hazard potential classification.

Based on the size and hazard classification, and in accordance with the Corps of Engineers guidelines, the Test Flood (TF) would be between the 100-year flood and one-half of the Probable Maximum Flood (PMF). Since the hazard potential is on the low side of the SIGNIFICANT category, the test flow into Supply Pond was taken as the 100-year flood.

The selected TF inflow of 2540 cfs results in an outflow of 2500 cfs at the dam. With all gates open and 1.0 ft. of stop logs in place at the spillway, the maximum flow elevation would be 5.4 feet above the spillway crest. This would result in flow 1.3 feet above the top of the dam.

Supply Pond Dam is in FAIR condition at the present time, but requires detailed investigations of the upstream face of all masonry structures, the building foundation wall of Pump Station No. 1, the need for permanent structural supports for the floor system of Pump Station No. 1, the drain blanket to alleviate sloughing of downstream channel slope where seepage was noted, and further hydrologic studies of spillway adequacy and implementation of the findings. Recommended remedial measures include pointing of all stone masonry to arrest seepage, cleaning of sluice gates, removing the wood frame gate house, clearing trees and debris from the downstream channel, monitoring seepage for change in quantity of flow, repairing all spalled concrete, checking cause of outlet gate leakage, instituting a program of annual technical inspections, and developing a formal warning system to alert downstream people in case of emergency.

The recommendations and improvements outlined above should be implemented within one year of receipt of this report by the owner.

THE STATE OF NEW HAMPSHIRE
WILLIAM S. ZOINO
No. 3226
REGISTERED PROFESSIONAL ENGINEER

REGISTERED PROFESSIONAL ENGINEER
NICHOLAS ANTHONY CAMPAGNA, JR.
No. 21,006
CIVIL
STATE OF CALIFORNIA

William S. Zoino
N.H. Registration 3226

Nicholas A. Campagna, Jr.
California Registration 21006

This Phase I Inspection Report on Supply Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph W. Finegan, Jr.

JOSEPH W. FINEGAN, JR., CHAIRMAN
Chief, Reservoir Control Center
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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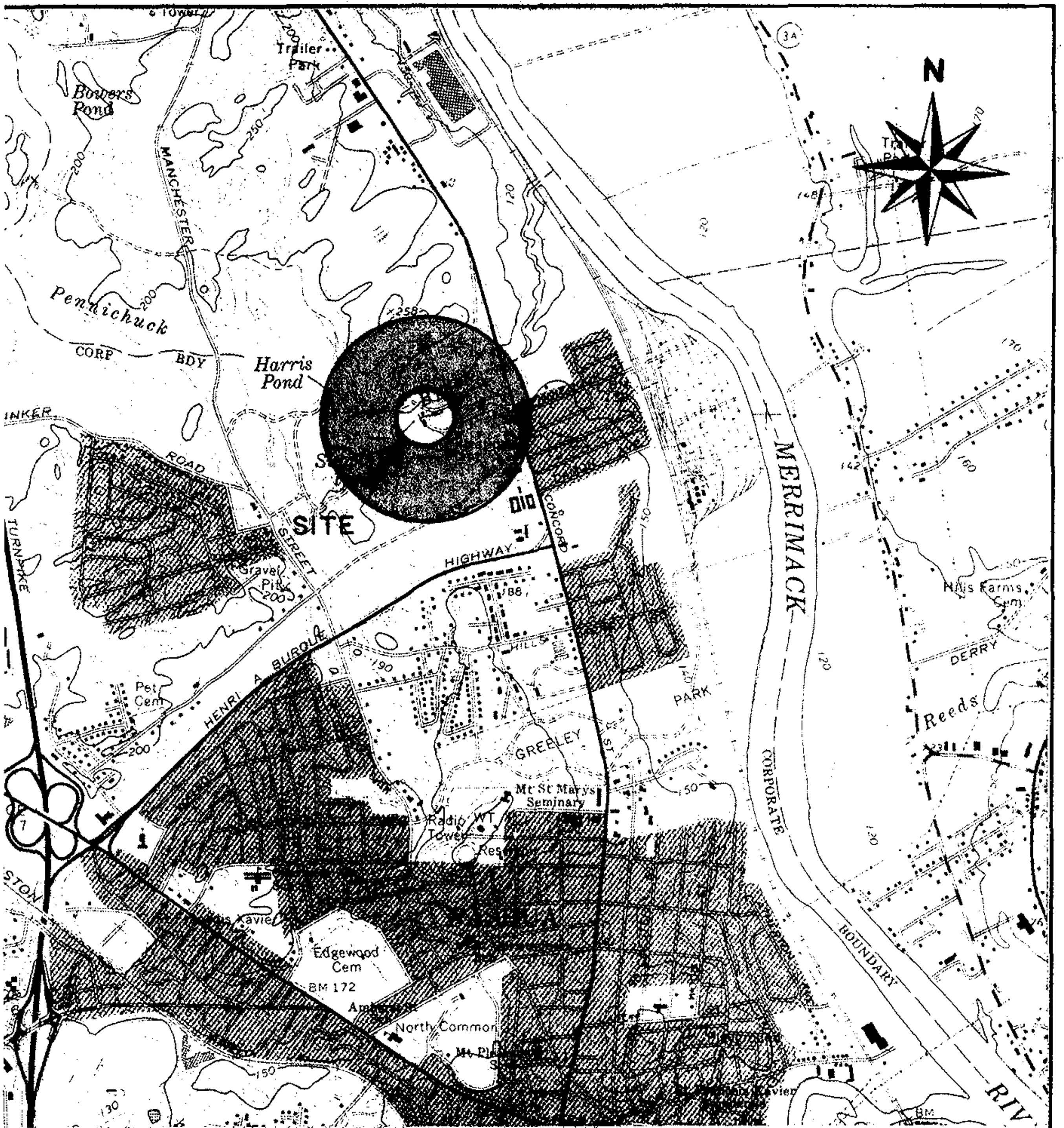
Overview of spillway from downstream channel

Overview of dam from right abutment upstream

Overview of dam from left upstream side



\- SCALE -

1000 2000 4000 FT.

FROM: USGS NASHUA NORTH, N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

SUPPLY POND DAM — NEW HAMPSHIRE

SCALE AS NOTED

DATE OCTOBER 1978

FILE No. 2201

PHASE I INSPECTION REPORT

SUPPLY POND DAM

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of November 28, 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW 33-79-C-0013 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dam.

1.2 Description of Project

(a) Location

Supply Pond Dam lies on the Pennichuck Brook approximately 4.5 miles north of the center of the city of Nashua, New Hampshire. The dam is located approximately 1,000 feet upstream from the point where U. S. Route 3 crosses Pennichuck Brook. The dam is readily accessible from Route 3 via an access road leading to the Pennichuck Water Works Water Treatment Plant. The portion of the USGS Nashua North, N.H. quadrangle presented previously shows this locus. Figure 1 of Appendix B presents a detail of the site developed from the inspection visit and the quadrangle map.

(b) Description of Dam and Appurtenances

This dam consists of an earth-filled embankment with core walls, a brick bearing wall pump house identified as Pump Station No. 1, and a gravity type cemented stone masonry spillway. The overall length of the dam is approximately 550 feet of which 34 feet is a gravity type cemented stone masonry spillway. A wood frame gate house, approximately 19 feet by 15 feet in size, is located immediately upstream of the left end of Pump Station No. 1. Another pump station (Pump Station No. 4) is located approximately 15 feet downstream of a gravity stone masonry retaining wall. The wall is continuous with the spillway and extends into the left bank as a core wall for an undetermined distance.

The gravity spillway structure which has a back batter of 5 horizontal to 12 vertical and a front batter of 2 horizontal to 12 vertical is founded on bedrock and is bridged by a 3 span shallow reinforced concrete arch. Three 10 foot clear openings between the arch supports form the spillway crest. The spillway crest consists of a concrete cap and is equipped with flashboards 12 inches high. Two 3.0 foot by 4.2 foot steel gates operated by means of screw jacks (worm gears) are located at either end of the spillway. The invert elevations of the sluice gates are approximately 17.5 feet below the spillway elevation. There are 7 weep drains penetrating through the downstream face of the spillway; five being randomly spaced 2 to 4 feet below the spillway crest, the remaining two being approximately 2 and 4 feet above the channel bed. A perforated 3 inch P.V.C. pipe is supported on the front face of this structure; its function is to jet spray water on this upstream side of the spillway to prevent ice build-up during the winter months.

(c) Size Classification

The dam's maximum impoundment of 245 acre-feet and maximum height of 28 feet ± are below the 1,000 acre-foot limit and 40 foot height for the SMALL size category as defined in the "Recommended Guidelines."

(d) Hazard Potential Classification

In the event of a failure of the dam the resultant water flow would probably cause significant damage to a downstream pump station and conduits which carry part of the water supply for the city of Nashua. In addition, the flow would be expected to top the Route 3 bridge immediately downstream, probably resulting in significant damage to the bridge. There is a remote possibility of loss of life in the event of a dam failure. For these reasons, a SIGNIFICANT hazard potential classification is warranted.

(e) Ownership

The Pennichuck Water Works owns this dam. The Pennichuck Water Works has offices at 11 High Street, Nashua, New Hampshire 03060.

(f) Operator

The Pennichuck Water Works operates the structure. Personnel involved in the operation of the dam are Steve Gorman, V.P., who can be reached by telephone at 603-882-5191, and Steve Scully and Henry Burpee at the Water Treatment Plant who can be reached at 603-882-1391.

(g) Purpose of Dam

At present the dam is being used to retain water used by the Pennichuck Water Works to supply the city of Nashua, N.H. The water flows directly from Supply Pond into the water treatment plant located just downstream from the dam. The dam is occasionally used to generate power to operate pumps by diverting water through Pump Station No. 4.

(h) Design and Construction History

Available records indicate that the dam was originally constructed in 1870 to replace an earlier earth dam which washed out in 1866, and in all probability, the two pump stations were constructed at the same time. At some later date, based on the 1914 drawings, modifications were made to the dam which consisted of constructing the gravity masonry spillway and the extension of the gravity stone masonry dam into the left bank.

(i) Normal Operational Procedures

The water levels at Supply Pond are controlled by adjusting the flow from Harris Pond into Supply Pond. By regulating the flow from Harris Pond into Supply Pond the water level at Supply Pond is kept below the spillway elevation. From Monday through Friday the water levels at Supply Pond are read daily by visual observation. Readings of water levels are not taken on weekends except during periods of high runoff. The normal procedure is to reduce the flow through the outlet gates at Harris Pond on weekends to accommodate the reduced demand. The gates are opened some more on Monday of each week to adjust for the weekday demand. Because the inflow to Supply Pond is controlled as it is, the sluice gates are used only to drain the pond and are not used during normal dam operation. The 30 inch siphon pipe leading to Pump Station No. 4 is occasionally used to drain the pond and to generate power for use in pumping. The 30 inch siphon will also be used for water supply upon completion of the new water treatment plant presently being constructed. During the winter months water is sprayed on the upstream face of the spillway through a 3 inch perforated P.V.C. pipe to prevent ice build-up.

1.3 Pertinent Data

(a) Drainage Area

Supply Pond receives runoff from 25.4 square miles of moderate to steeply sloping forested terrain. The Pennichuck Brook is the primary source of water to the pond. There is no development immediately around the pond because of its use as a water supply for the city of Nashua. The water treatment plant immediately downstream is the closest development to the dam itself.

(b) Discharge at Damsite

(1) Outlet Works

The outlet works at the dam consist of two 3 foot by 4.2 foot gates located in the spillway and a 30 inch diameter pipe leading to Pump Station No. 4. The invert elevations of the two 3 foot by 4.2 foot gates are 119.3 and 119.1. The invert elevation for the 30 inch pipe is elevation 114.0. At the time of inspection one foot of stop logs was in place above the spillway's permanent crest.

(2) Maximum Known Flood at Damsite

No official records of the historical high water levels are available for these dams, but according to officials of the Pennichuck Water Works, this dam has never been overtopped. The largest flood in the area was the flood of 1936 which resulted in tailwater below the dam rising to approximately elevation 126, but the dam itself was not overtopped.

(3) Spillway Capacity at Maximum Pool Elevation (Stop logs in place)

514 cfs at El. 140.8

(4) Gated Capacity at Normal Pool Elevation

483 cfs at El. 136.8 for the two 3 foot by 4.2 foot gates

112 cfs at El. 136.8 for the 30 inch waste pipe

(5) Gated Capacity at Maximum Pool Elevation

535 cfs at El. 140.8 for the two 3.0 foot by 4.2 foot gates

122 cfs at El. 140.8 for the 30 inch waste pipe

(6) Total Discharge Capacity at Maximum Pool Elevation

1172 cfs at El. 140.8

(c) Elevation (feet above MSL)

(1) Top of Dam: 140.9

(2) Maximum Pool: 140.9

(3) Recreational Pool: 136.8

(4) Spillway Crest: 136.8
With Stop Logs: 137.8

(5) Streambed at Centerline of Dam: 113 ±

(6) Maximum Tailwater: 1936 flood tailwater flooded the D & M pump station. (No. 4) Approximately El. 126

(d) Reservoir

(1) Length of pool - recreational: 1300 ft. ±
- maximum: 1300 ft. ±

(2) Storage - recreational pool: 171 acre-feet ±
- maximum pool: 245 acre-feet ±

(3) Surface area - recreational pool: 18 acres ±
- maximum pool: 20 acres ±

(e) Dam

(1) Type: Earth embankment with a gravity stone masonry spillway

(2) Length: 550 feet

(3) Height: 28 feet ±

(4) Top width: Varies - 5 feet at spillway

(5) Side slopes: Spillway Section - U/S 2 horizontal to 12 vertical
- D/S 5 horizontal to 12 vertical

(6) Zoning, impervious core, cutoff, and grout curtain: Unknown

(f) Spillway

(1) Type: Gravity, concrete- capped, stone masonry

(2) Length of weir: 30 feet (3 sections at 10 feet)

(3) Crest elevation: 136.8
with stop logs in place - 137.8

(4) Gates: Two 3 foot by 4.2 foot gates with inverts at El. 119.3 and El. 119.1

(5) U/S channel: Broad approach from pond

(6) D/S channel: Narrow rocky bottom with steep side slopes

(g) Regulating Outlets

As mentioned previously, the dam's regulating outlets are two 3 foot by 4.2 foot sluice gates and a 30 inch pipe which is diverted to Pump Station No. 4 and can be used to waste water. The gates are controlled by screw jacks and have inverts at El. 119.1 and 119.3. The 30 inch pipe has an invert elevation of 114.0. The gates are used only to drain the pond while the 30 inch pipe is used infrequently. The stop logs on the spillway are removable but are not moved in normal operation of the dam.

SECTION 2 - ENGINEERING DATA

2.1 Design Records

The design of this dam is quite simple and incorporates no unusual features. No original design drawings or calculations are available. Significantly lacking are data concerning the length of the stone masonry core wall, the character of the earth embankment, and the foundation conditions.

2.2 Construction Records

The plans and construction records that are available are of little value in evaluating the structure. The drawing included in Appendix B is useful only in evaluating the stone spillway and otherwise provides little useful data.

2.3 Operational Records

The owner operates the dam in a manner consistent with its intended purpose and engineering features.

2.4 Evaluation of Data

(a) Availability

The absence of design drawings and calculations is a significant shortcoming. An overall unsatisfactory assessment for availability is therefore warranted.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment of the dam is thus based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the drawings available, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Supply Pond Dam is in FAIR condition at the present time. This structure requires investigations pertaining to the source of seepage through the foundation of former Pump Station No. 1 and further investigations into the structural stability of the building foundation with special emphasis on the geometry of the wall retaining the pond, settlement of intermediate columns, and relocation of stone columns resulting in cantilevering of stone headers.

(b) Dam

(1) Embankment

The general condition of the earth embankment is good. No significant settlement or horizontal movement of the embankment is visible. The conditions at the abutments are good and no sloughing or erosion of the embankments was observed. No unusual downstream seepage was observed through the embankment.

(2) Left End Wall

Observations of both the upstream and downstream faces of this wall have revealed that it is in good condition with all masonry joints tightly pointed.

(3) Spillway Structure

The downstream side of the spillway structure is generally in good condition with the exception of minor efflourescence at mortared joints and seepage at specific locations. This seepage occurs through a weep drain located approximately 4 feet above the downstream channel bed (5 g.p.m.), at the lower right extremity of the structure, and through the sluice gate outlet tunnels (10 g.p.m. each). The constant flow of water discharging through the two outlet tunnels indicates that the gates are not fully seated.

Although the gates were not operated at the time of this inspection, the owner's representative indicated that the gates are operable.

The three span service bridge structure deck exhibits minor surface spalling and a transverse crack. The spalling can be attributed to excessive surface trowelling of concrete and the random cracks can be attributed to expansion of the concrete deck. There is also considerable random surface cracking and efflourescence on the underside and at the fascias of this service bridge.

(4) Pump Station No. 1

Because the upstream face of this building is part of the overall continuity of the dam, its present condition is a prime factor in determining the overall safety of the dam.

This is a brick masonry wall bearing structure with the main level located at the dam crest elevation. Access to this building is gained from either the concrete arch service bridge on its left side or from the earth embankment on the right. The lower level of this building is constructed with stone masonry. Access to the front portion of the basement is by means of a 2 foot x 2 foot manhole opening, the rear access by means of stairs. The main floor of the building is supported by stone headers which in turn are supported by stone columns approximately 16 inches square. The floor of the lower level consists of stone slabs. The front portion of the basement has been filled with earth and debris. There are numerous brick arch openings in the lower level with some of the arches sealed with masonry. The foundation walls of the building consist cemented stone masonry; its upstream face serves as a retention structure for Supply Pond. A bricked-up arch opening is located on the left end of this foundation wall. This opening was the former outlet for waste discharges. A penstock, which has its origin in the gate to the right of the bricked up arch, penetrates through the upstream foundation wall and into the building's lower level.

This penstock branched into at least three directions within the building to serve now removed generators. The remains of two timber sluice gates are in evidence within the gate house.

The upstream face of the building wall consists of random stone masonry, cemented and pointed at the upstream exposed surface. It was observed that the stone columns which support the stone headers have experienced past settlement. The openings which developed between the top of the columns and the granite headers have been shimmed with different types of materials. Iron pipes or parts of gate ratchets were used to shim the headers. The size of the shims varies up to 5 inches in thickness. From visual observations it is evident that some of the columns have been relocated after they became non-functional. These columns were reset at adjacent convenient locations without regard to the structural systems being supported. One column which was originally set at the location where two headers butt together has been reset at an inappropriate location resulting in the cantilevering of two stone headers for lengths from 3 to 4 feet from their support. The penstock could not be inspected for signs of seepage because of the partial filling of the basements with earth and debris.

There is evidence of seepage below the filled area. The rate of seepage could not be established because of the lack of access to the original level of the basement floor. However, auditory observations of the discharge flowing through the upstream foundation wall and the basement of the building indicate that the seepage is concentrated. The previously mentioned arched opening was bricked up with open jointed random stone masonry. Furthermore, visual observations do not indicate that the upstream wall of this building would be a self-supporting gravity type of wall. Investigations did not clearly demonstrate that the top width and back batter of this wall is consistent with the geometry of the adjacent spillway structure. It can be assumed that the cross walls are actually acting as buttresses and are assisting in holding this wall in place and increasing its structural stability.

The left sidewall at Pump Station No. 1 has a drain pipe approximately 6 feet above the channel bed with active seepage through the pipe. There is also joint seepage on this sidewall of the building. This seepage and the active drain pipe confirms the fact that a large amount of seepage is flowing through the upstream face of the foundation wall. The seepage discharging through the left sidewall is at the rate of 10 to 20 gpm.

(5) Gate House

The gate house itself is in POOR condition. The timber columns and framing supports exhibit a high degree of rot. The gates which were located in this building have completely deteriorated. At the present time the main floor of this structure is being used for storage.

3.2 Evaluation

Supply Pond Dam is in FAIR condition based primarily upon the amount of seepage through the dam. Most of the major components were accessible for examination, although it was not possible to observe the seepage through the foundation wall of Pump Station No. 1 or to observe the upstream face of stone masonry structures to determine this condition.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

The water level in the pond is read daily during the week and on weekends during periods of high runoff by representatives of the Pennichuck Water Works. The pond level is generally below the spillway elevation and is controlled primarily by adjusting the inflow from Harris Pond. When inflow exceeds the needs of the water system, water can be wasted or used for power generation through the 30 inch siphon pipe.

4.2 Maintenance of Dam

No formal maintenance program exists for the dam. The dam is observed regularly by Pennichuck Water Works (PWW) personnel for needed maintenance and according to representatives of PWW, the maintenance and repairs are performed as necessary.

4.3 Maintenance of Operating Facilities

The two sluice gates are not used regularly thereby precluding any regular maintenance procedure. The 30 inch siphon pipe is used for water supply so it is maintained by the Pennichuck Water Works. The stop log structure over the spillway is very simple and requires no real maintenance.

4.4 Description of Warning System

A remote sensing unit located at the Snow Station recording the levels of Harris Pond is the only real warning system for Supply Pond. However, the regular (daily during the week) readings of levels in Supply Pond, Harris Pond and Bowers Pond (upstream of Harris Pond) is the real method of warning used by the Pennichuck Water Works. The operators have found the remote sensing system to be unreliable at times.

4.5 Evaluation

The dam's present FAIR condition is responsible largely because of the seepage through the spillway and Pump Station No. 1. Routine maintenance for pointing of masonry needs to be performed and the causes of the seepage investigated more thoroughly. Because of the frequency of water level readings and the conscientiousness of the personnel involved, the warning system for the dam is adequate.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) Available Data

Data sources available for Supply Pond Dam include prior inventory and inspection reports and a copy of an Anderson-Nichols Company Flood Insurance Study. The New Hampshire Water Control Commission's "Data on Dams in New Hampshire" (April 10, 1939), the New Hampshire Water Resources Board's "Inventory of Dams and Water Power Developments" (August 25, 1936), and the Public Service Commission of New Hampshire's "Dam Record" (August 31, 1936) provide much of the basic data for the dam. Inspection reports from July 9, 1930; June 19, 1940; June 22, 1951; and October 24, 1973 are also available, as well as 1975 letters between the New Hampshire Water Resources Board and the dam's owners (Pennichuck Water Works) regarding repairs needed at the dam. The Pennichuck Water Works provided 1914 plan and sections of the dam by Metcalf and Eddy, a 1940 map of the watershed area, and piping diagrams for the pump stations near the dam.

Anderson-Nichols Company (ANCO) provided copies of 1977 work for a Flood Insurance Study (FIS), including Pennichuck Brook and Supply Pond. This work included a rating curve; a storage-elevation curve; 10, 50, 100 and 500 year peak inflows and outflows; and cross-section data at various points on Pennichuck Brook (including the dam).

(b) Experience Data

An eighteen year record of peak outflows at Holt's Pond is included in ANCO FIS work. Holt's Pond is above Harris Pond, which is above Supply Pond in the linked series of ponds on Pennichuck Brook. ANCO has developed a relationship between Holt's Pond outflow and Supply Pond inflow, which they used to determine a flow recurrence-interval relationship.

(c) Visual Observations

Supply Pond Dam is a stone masonry and earthen embankment structure on the Pennichuck Brook just north of Nashua, New Hampshire. The spillway has a vertical stone masonry face with an overall length of 34 feet with a 30 foot clear opening and a crest elevation at 136.8 feet above Mean Sea Level (MSL).

A concrete walkway just above the spillway has supports that divide the spillway into three 10 foot long bays. At the time of the inspection, each bay had a one foot high stop log in place. The water level was observed to be 0.6 feet below the spillway crest (an elevation of 136.2 feet MSL) with the only discharge through the dam being seepage out of the gate tunnels from the unseated gates, through the weep holes drains, through the masonry at the lower right extremity of the spillway, and through the upstream and left side walls of Pump Station No. 1.

The regulating outlets for the dam are two 3 foot by 4.2 foot gates located in the lower portion of the masonry spillway. Although these gates were not actually operated, representatives of the owner indicated that they are in working condition, but rarely used. A 30 inch diameter penstock through the dam and into an old pumping station building (just downstream and to the left of the spillway) can be used either to provide water supply or to waste water. Additional flow regulation is provided by the operation of Harris Pond just upstream of Supply Pond. A 72 inch diameter penstock from Harris Pond also enters the pump station just below Supply Pond and can be used for water supply, for power generation, or to waste water. Since the ponds are jointly regulated to provide water supply for Nashua and to minimize water waste, water almost never passes over the Spillway at Supply Pond.

To the right of the gate house an earthen embankment topped by a paved access road forms the crest of the dam. This extends for a distance of about 250 feet at an elevation of 140.9 MSL. To the left of the spillway the walkway extends about 40 feet more over an earthen embankment, also at elevation 140.9 feet.

Downstream of the dam the Pennichuck Brook channel has high banks and is relatively steeply sloping. A newly constructed water supply conduit bridge located about 225 feet downstream of the dam has a top elevation of 125 feet and two 60 inch diameter culverts. About 1100 feet further downstream the stream passes under New Hampshire Route 3 via a 15 foot by 15 foot box culvert. Beyond this point the stream channel widens considerably for the remaining mile or so to its confluence with the Merrimack River.

(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This analysis requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately-sized Test Flood. None of the original hydraulic and hydrologic design records are available for use in this study.

Guidelines for establishing a recommended Test Flood based on the size and hazard classifications of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1000 acre feet and height of less than 40 feet classify this dam as a SMALL structure.

The hazard potential for this dam is considered to fall within the SIGNIFICANT category. This is based on the possibility of structural damage to Nashua's water supply conduits, crossing Pennichuck Brook immediately below the dam, and to the Highway 3 bridge downstream. Although there is some potential for loss of life in the event of dam failure, this is considered minimal since there are no residential structures downstream. The possibility of significant economic damage, but low loss of life potential make the SIGNIFICANT classification appropriate.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as SMALL in size with a SIGNIFICANT hazard potential would be between the 100-year flood and one-half times the Probable Maximum Flood (PMF).

The previous ANCO FIS provided 10, 50, 100 and 500-year inflows to Supply Pond. The FIS work by ANCO produced flow rates per square mile of drainage area that are low by comparison with typical rates for the region. The 100-year flow of 440 cfs is equal to about 17.3 csm. The reason for these low flows is the character of the basin upstream of Supply Pond Dam. The basin is swampy, with three large ponds (Bower's, Holt's, and Harris) upstream.

However, it is apparent from ANCO's work that the primary control causing low flow is the culvert across Pennichuck Brook at Route 101-A. The culvert controls 19 sq. miles of the drainage area, and drastically reduces peak flows.

For the purposes of this Test Flood Analysis, It does not seem proper to allow a man-made construction such as the Route 101-A culvert, which might be enlarged or removed at any time, to determine Test Flood inflows. Therefore, ANCO's FIS flow values would not apply to this study.

The "Recommended Guidelines" suggest that if a range of values is indicated for the Test Flood, the magnitude should be related to the hazard potential. Since the hazard is on the low side of the SIGNIFICANT category, the test inflow to Supply Pond is taken to be the 100-year flow.

The March 1936 storm is generally accepted as approximating the 100-year storm for New England. Although the flows for Pennichuck Brook are not available, the 1936 flood produced flows of around 100 csm for drainage areas similar in size and character to the Pennichuck.

A test inflow based on 100 csm or 2540 cfs is routed through Supply Pond using the stage-discharge and storage-elevation curves shown in Appendix D. With all gates open and 1.0 ft. of stoplogs in place at the spillway, the peak outflow from the Test Flood would be about 2500 cfs. The peak water surface elevation would be 142.2 ft. MSL, 5.4 ft. above the spillway crest, 1.3 ft. above the top of the dam.

5.2 Hydrologic/Hydraulic Evaluation

Since it is possible that the degree of overtopping created by the test flood would cause damage to Supply Pond Dam, the provision of additional outlet capacity should be considered. This could be accomplished through either modifications to increase the spillway capacity or additional outlet conduit capacity.

5.3 Downstream Dam Failure Hazard Estimate

The peak outflow at Supply Pond Dam that would result from dam failure is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." Failure is assumed to occur as soon as the dam crest is overtopped, at an elevation of 140. 9 feet. This is 4.1 feet above the spillway and about 30 feet above the stream bed. It is assumed that a 39 foot gap is opened in the dam. The peak failure outflow through this gap, over the spillway, and through the gates and waste pipe would be 12,000 cfs.

This flow would probably cause significant damage to the pump station and conduit crossings located immediately downstream of the dam.

The conduits carry part of the water supply for the City of Nashua. Since the pump station is usually unoccupied, the potential for loss of life at this site would be low.

The only structure along the channel between the dam and the highway (Route 3) bridge will be the Pennichuck Water Works Treatment Plant which is presently under construction. The lowest part of this plant will be 29 feet above the streambed. Since the flood wave downstream of the dam would not be expected to exceed more than two-thirds of the original height of 30 feet, the Water Treatment Plant should not be affected.

Because of the comparatively steep slope and narrow channel downstream of the dam, there would be little attenuation of flow between the dam and the highway bridge some 1100 feet downstream. Therefore, the assumed peak flow at the bridge is 12,000 cfs. The Highway 3 bridge consists of a 15 foot x 15 foot conduit with an invert 31 feet below the roadway. Using a nomograph in FHWA Hydraulic Engineering Circular No. 5 for the conduit and a simple weir equation for the roadway, the estimated elevation necessary to pass 12,000 cfs is 3.5 feet above the road surface. This could result in significant damage to the bridge. Also, because of the high rate of rise expected, there would be some hazard to the occupants of any vehicles that happened to be passing this location on this heavily travelled highway.

Below the Route 3 bridge, Pennichuck Brook widens before feeding into the Merrimack River. It is probable that the flood wave would quickly attenuate downstream of the bridge.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

The field investigation revealed no significant displacement or distress, which would warrant the preparation of structural stability calculations, based on assumed sectional properties and engineering factors. However, field investigations should be conducted in order to clearly ascertain the configuration and structural stability of the upstream foundation wall of Pump Station No. 1. The causes and extent of seepage through the spillway and upstream wall of Pump Station No. 1 should be investigated more thoroughly.

(b) Design and Construction Data

No plans or calculations of value to a stability assessment are available for this dam.

(c) Operating Records

There are no formal operating records for this dam. Thus, no information concerning the stability of the dam during periods of high flow is available. The dam did withstand the flood of 1936 which was one of the largest floods in the area.

(d) Post Construction Changes

The numerous alterations conducted during the lifetime of this dam did not reduce the structural stability of this dam.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase 1 guidelines, does not warrant seismic analyses.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Supply Pond Dam is in FAIR condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The engineering studies and recommendations regarding the foundation seepage and configuration of the building foundation wall should be implemented by the owner within one year of receipt of the Phase I Inspection Report.

(d) Need for Further Investigation

Additional investigations should be performed by the owner as outlined in paragraph 7.2.

7.2 Recommendations

It is recommended that the services of a registered professional engineer be retained to:

(a) Make a detailed examination of the upstream face of all masonry structures with the pond lowered to a level allowing such examination.

(b) Conduct a detailed examination of the upstream building foundation wall at Pump Station No. 1 after earthfill and debris have been removed. Institute remedial structural repairs as required.

(c) Design and install permanent structural supports for floor system in building, as required.

(d) Design and provide a crushed stone drain blanket to alleviate sloughing of downstream channel slope where seepage is noted.

(e) Make further hydrologic studies of the spillway adequacy.

The findings for (a) through (e) should be implemented.

7.3 Remedial Measures

(a) Clean debris from around sluice gates outletting through the spillway structure. Service and operate sluice gates at regular intervals.

(b) Point all stone masonry, as necessary, to arrest seepage through the spillway structure and the building foundation wall.

(c) Remove the wood frame gate house.

(d) Institute a program of annual technical inspection of the dam.

(e) Develop a formal warning system to alert downstream people in case of emergency.

(f) Clear trees and debris from downstream channel.

(g) Monitor seepage for change in quantity of flow.

(h) Repair all spalled concrete.

(i) Check outlet gates to determine the cause of leakage and repair if necessary.

7.4 Alternatives

There are no meaningful alternatives to the above recommendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: October 31, 1978

NH 00123
SUPPLY POND DAM
Nashua, New Hampshire
Pennichuck Brook
NHWRB 165.06

Weather: Clear, 55°F

INSPECTION TEAM

Nicholas Campagna	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD)	Team Captain
William S. Zoino	GZD	Soils & Foundation
Robert Minutoli	GZD	Soil
Andrew Christo	Andrew Christo Engineers (ACE)	Structural
Paul Razgha	ACE	Structural
Richard Laramie	Resource Analysis, Inc.	Hydrology

Mr. Pattu Kesavan of the New Hampshire Water Resources Board accompanied the inspection team.

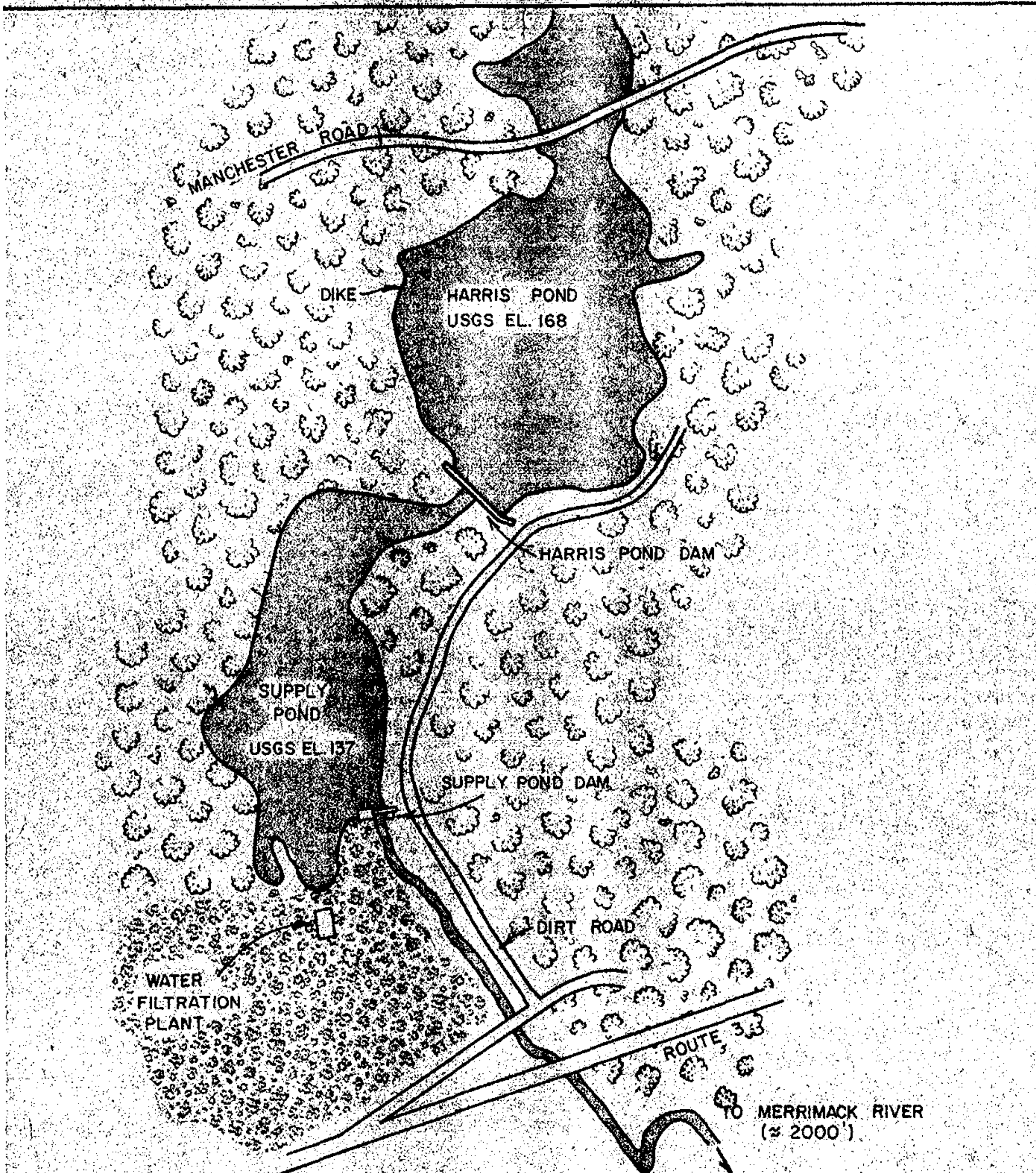
CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
EMBANKMENT		
Vertical alignment and movement	NAC	No deficiencies noted
Horizontal alignment and movement		No deficiencies noted; top width variable
Condition at abutments		No deficiencies noted
Trespassing on slopes		No evidence
Sloughing or erosion of slopes		None noted
Rock slope protection		None, except at left end of right embankment where there is a vertical stone masonry facing in good condition
Unusual movement or cracking at or near toe		None noted
Unusual downstream seepage		None noted in embankment area
Piping or boils		None noted
Foundation drainage features		No evidence of any
OUTLET WORKS		
A. Approach Channel		
Slope conditions		Broad approach from pond with moderate , stable banks
Bottom conditions	NAC	Bottom not visible

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Rock slides or falls	NAC	No rock near approach channel
Log boom		None
Control of debris		No debris evident behind dam
Trees overhanging channel	NAC	None
B. Left End Wall	PR	Good
C. Spillway		
Vertical and horizontal alignment		No deficiencies noted
Stone masonry		Minor efflourescence in mortar joints
Seepage		Approximately 5 gpm through weep hole drains and 2 gpm through masonry at lower right extremity. Approximately 5 to 10 gpm through each of two outlet tunnels
D. Concrete Service Bridge		
Condition of concrete		Fair
Spalling		Minor surface spalling
Cracking		Transverse crack on top surface, considerable random cracking on underside of bridge
Rusting or staining of concrete		None
Visible reinforcing		None
Efflourescence	PR	Considerable on underside of bridge

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
E. Pumping Station No. 1		
Upstream foundation wall	AC	Serves as retention structure for pond; seepage audible but could not be seen or located because of fill and debris
Left side wall		Outlet of seepage originating in the upstream foundation wall through weep drain and open joints in building foundation; approximate flow 10 to 20 gpm
Supporting Columns		Settled and shimmed
F. Gate House		
Timber column supports and framing		Rotted
Gates	AC	Deteriorated and abandoned
RESERVOIR		
A. Shoreline	NAC	
Evidence of slides		None noted
Potential for slides		Shoreline stable
B. Sedimentation		None noted
C. Upstream hazard areas in the event of back-flooding		No development along shore of pond
D. Changes in nature of watershed (agriculture, logging, construction, etc.)	NAC	None noted

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
DOWNSTREAM CHANNEL		
A. Slope Conditions	NAC	Right hand slope about 50 to 125 feet downstream, seepage approximately 3 to 6 gpm, 4 to 8 feet above channel bottom. Seepage is clean and clear. Minor sloughing occurring.
B. Rock Slides or Falls		None noted
C. Control of Debris		Considerable vegetation and trees growing in the channel
D. Other Obstructions	NAC	None at present; however, construction of embankment with two culverts is to be constructed in another month
OPERATION AND MAINTENANCE FEATURES		
A. Reservoir Regulation Plan		
Normal procedure	NAC	Water level controlled by 18-inch pipes in spillway at upstream Harris Pond Dam
Emergency procedure		Sluice gates could be opened by personnel at adjacent treatment plant
Compliance with designated plans		Satisfactory
B. Maintenance		
Quality		Some maintenance repairs needed
Adequacy	NAC	Dam observed daily except Saturday and Sunday by treatment plant personnel

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

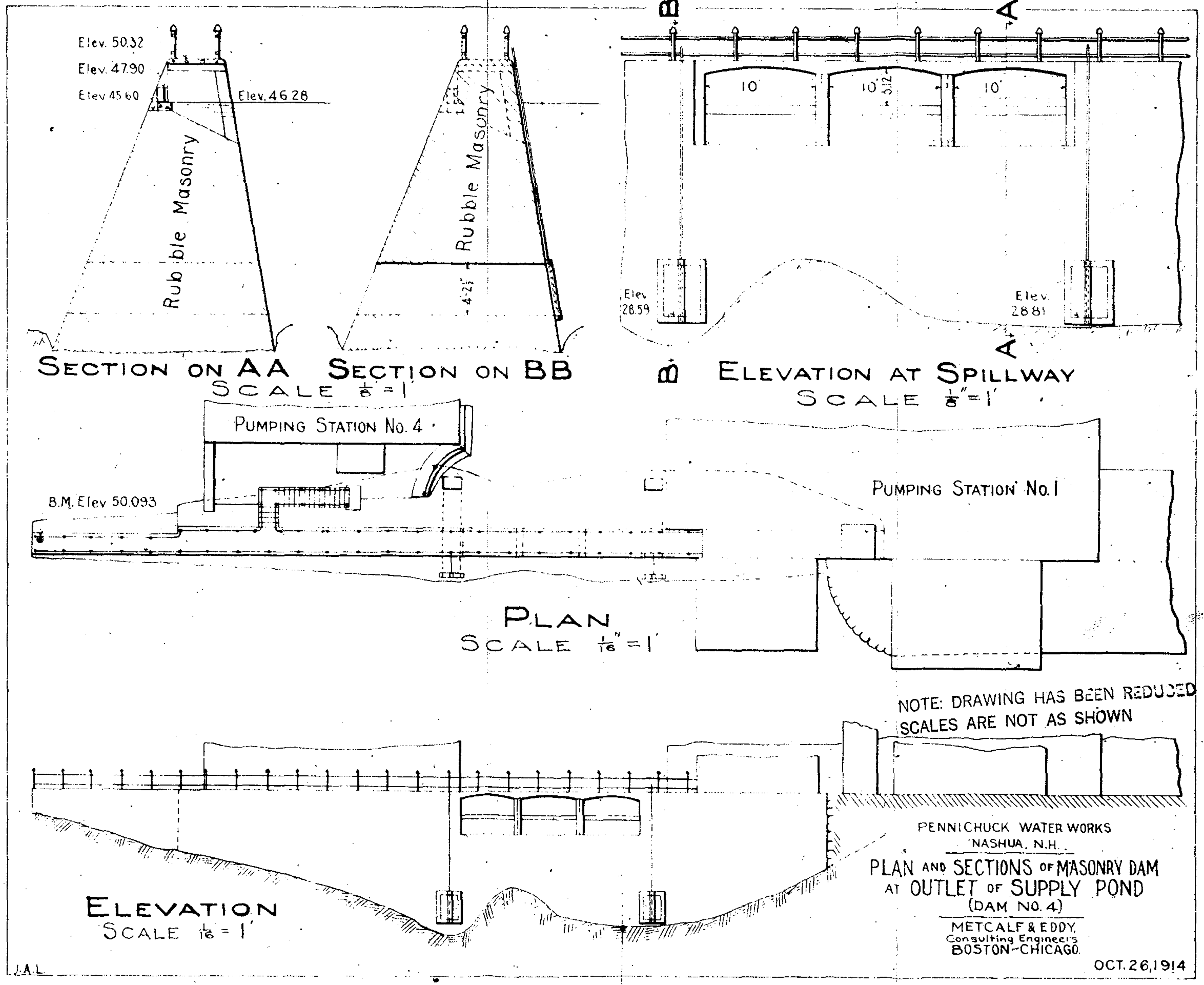
SITE PLAN

SUPPLY POND DAM — NEW HAMPSHIRE

FILE No. 2201

SCALE 1" ≈ 600'
DATE OCTOBER 1978

PLATE XV



B-3 2905-Z-714

The New Hampshire Water Resources Board (NHWRB), 37 Pleasant Street, Concord, N.H. 03301 maintains a comprehensive correspondence file on the dam dating back to the 1930's. Included in this file are:

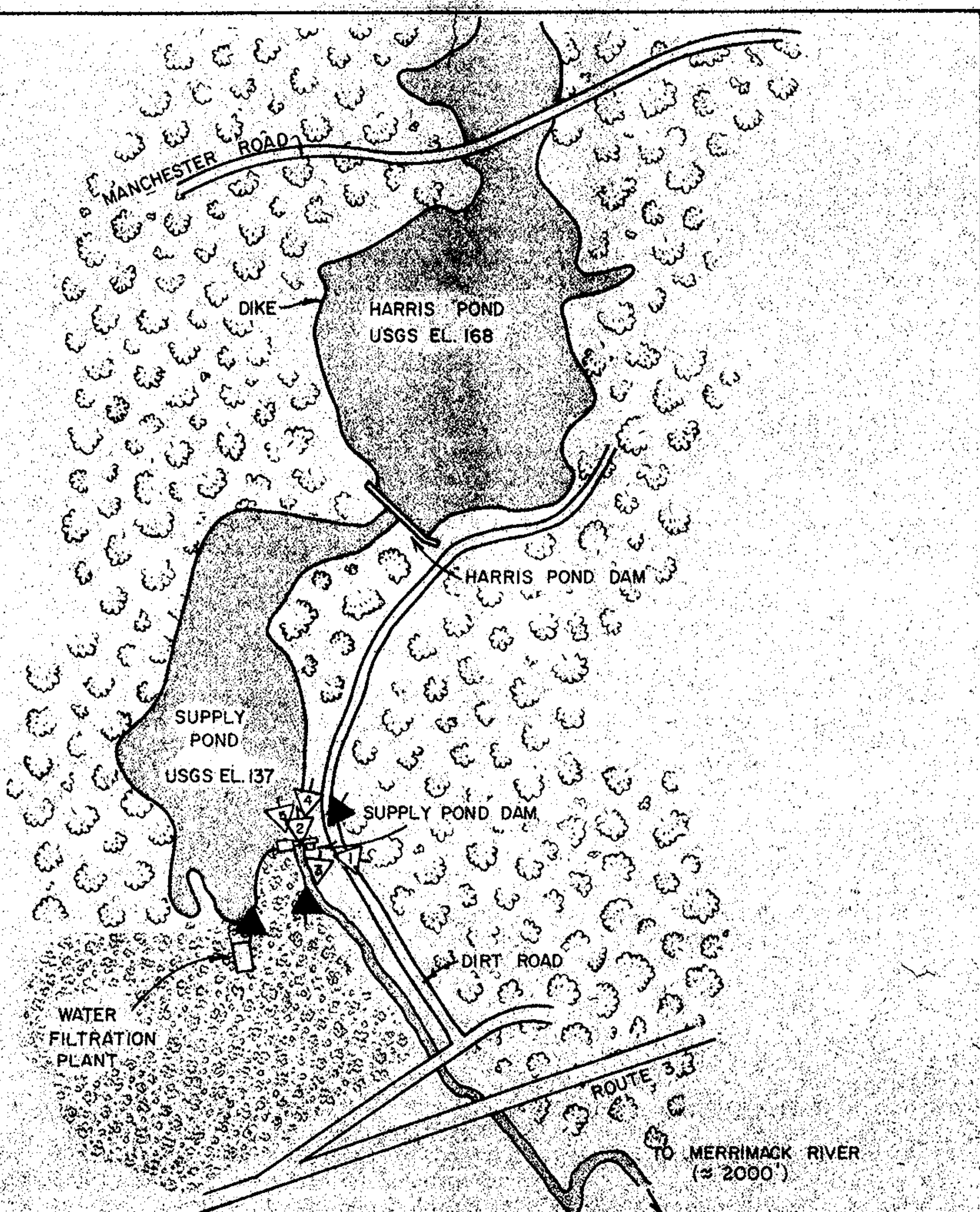
(a) Correspondence in 1975 between the NHWRB and the Pennichuck Water Works (PWW) regarding repairs that need to be made to the dam.

(b) Inspection reports of the dam made in October 1973, June 1951, April 1939, August 1936 and July 1930.

The Pennichuck Water Works maintains permanent records of the daily water level readings taken at this dam. The PWW has offices at 11 High Street, Nashua, N.H. 03060.

APPENDIX C

SELECTED PHOTOGRAPHS



OVERVIEW

APPENDIX C

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
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NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOCATION AND ORIENTATION OF PHOTOS

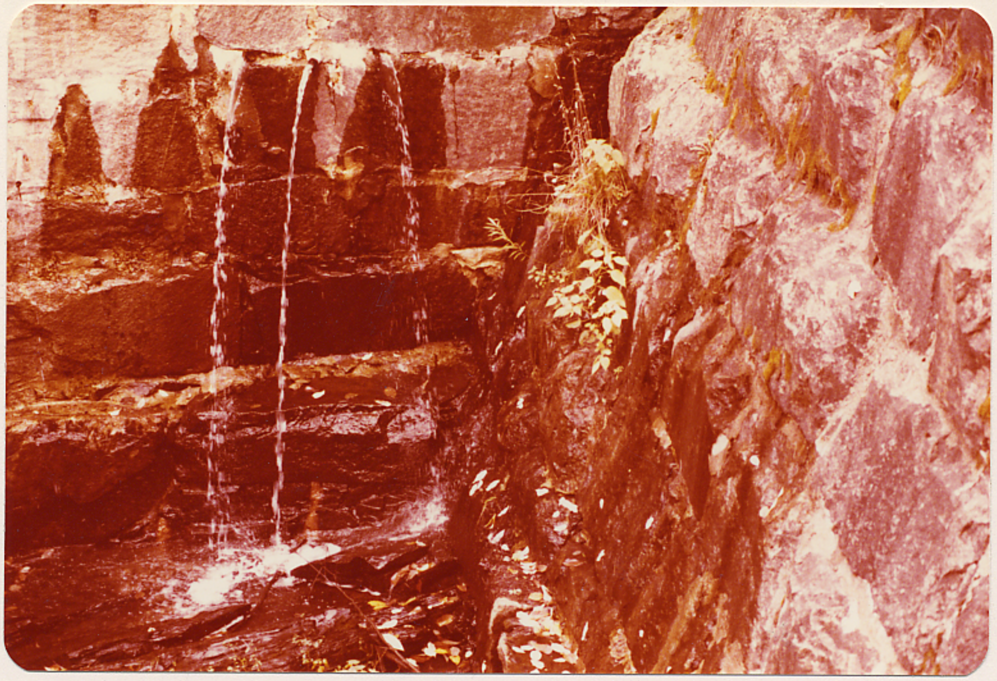
SUPPLY POND DAM

NEW HAMPSHIRE

FILE No. 2201

SCALE 1" ≈ 600'

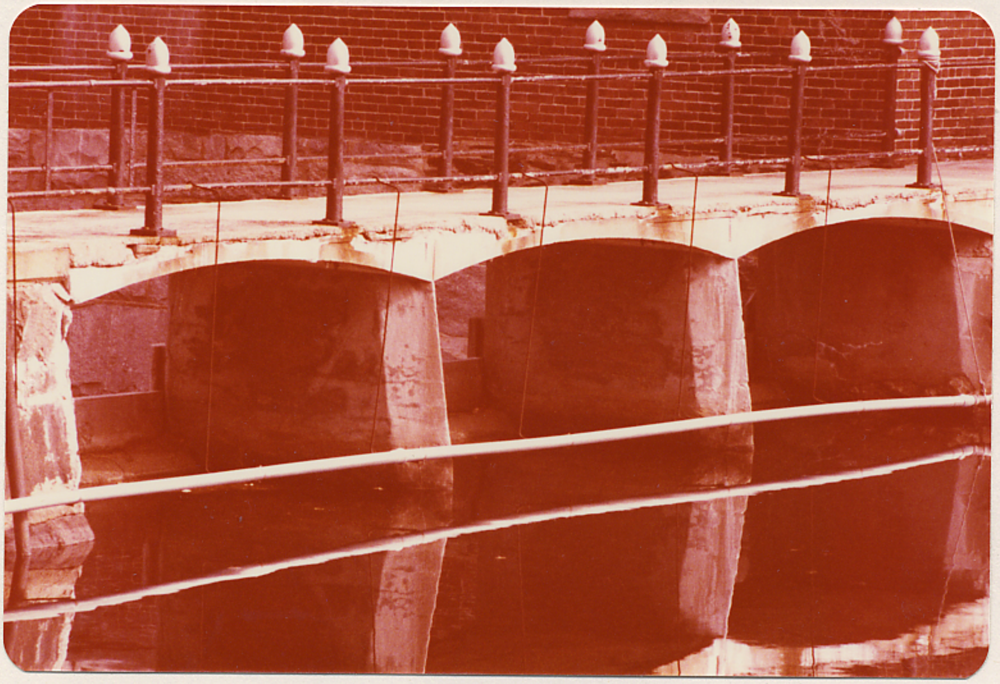
DATE OCTOBER 1978



1. View of seepage through wall of old powerhouse at junction with right side of spillway and through face of dam at same location

2. View of downstream channel from top of dam

3. View of water treatment plant earthwork on right side of downstream channel



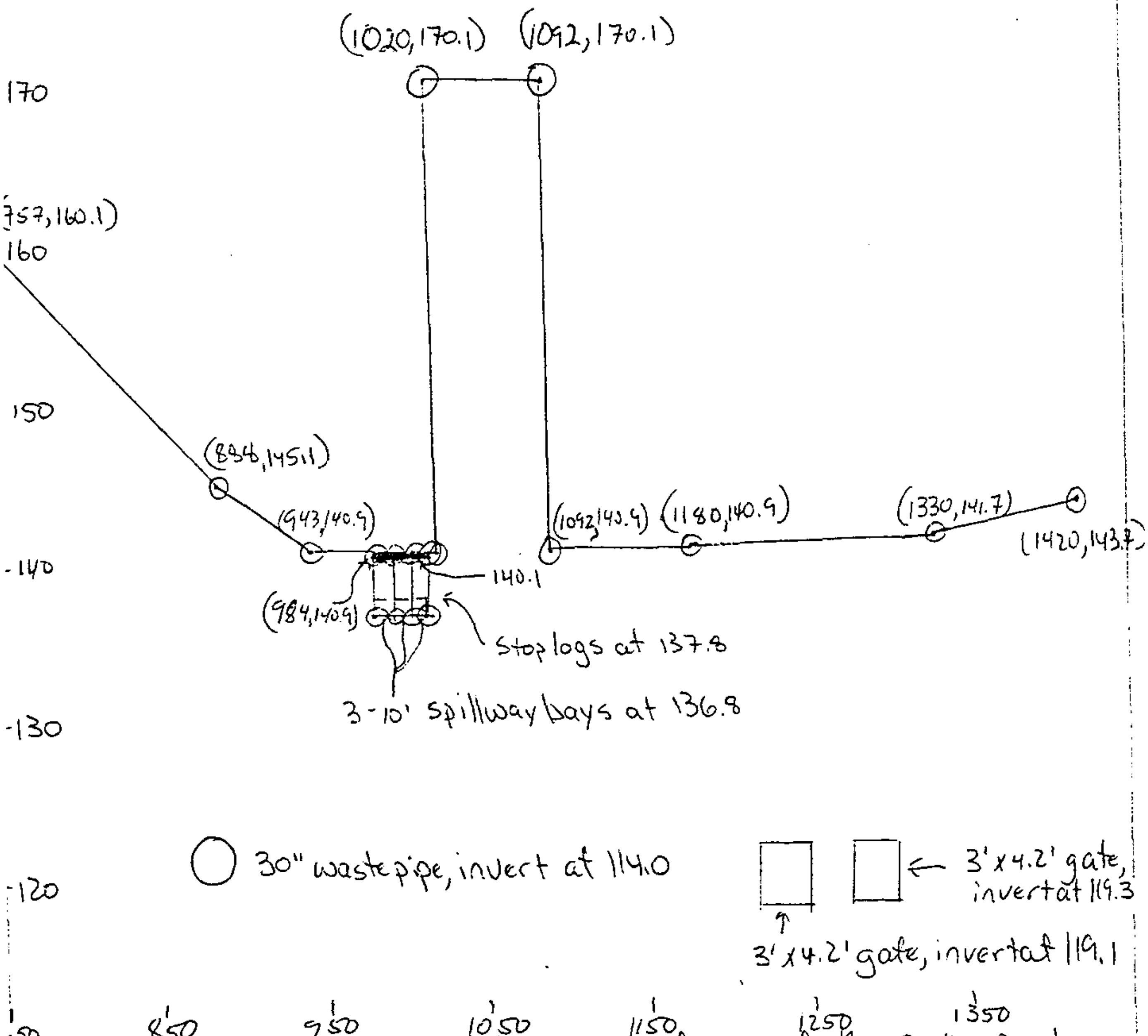
4. View of concrete deterioration on spillway piers and service bridge

5. View from upstream of general deterioration of old timber gatehouse controlling intake to old powerhouse

APPENDIX D

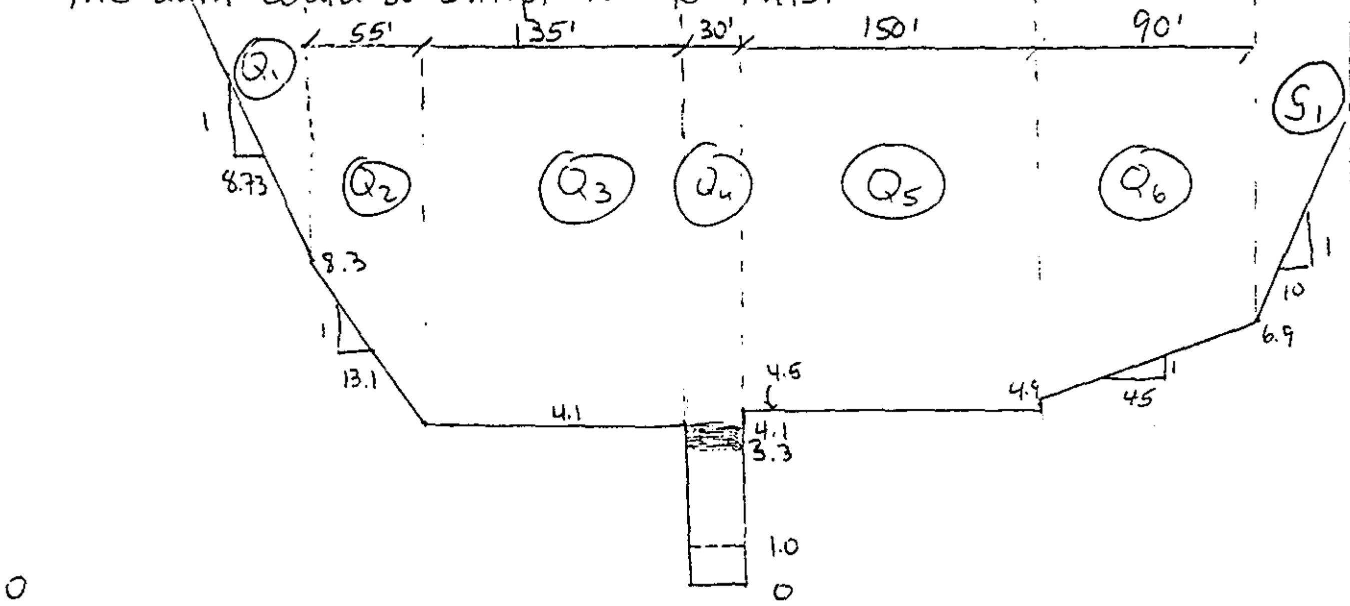
HYDROLOGIC/HYDRAULIC COMPUTATIONS

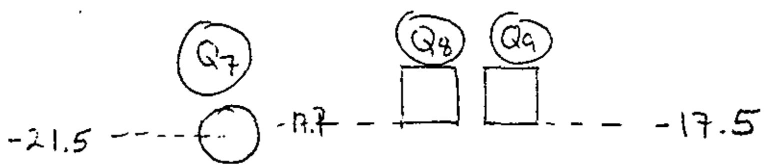
The information used to determine the cross-section at Supply Pond Dam was obtained from 1914 plans, piping diagrams, 1977 Anderson-Nichols Company (ANCO) survey data (for F.I.S. work), and field notes.



Assume that the 2-3'x4.2' gates and the 30" waste pipe are open in flood conditions. Assume 1ft. of stoplogs in place across the spillway.

The dam could be simplified to this:





Q_7, Q_8, & Q_9 are functions of h. ($h=0$ at 136.8, spillway crest.)

Q_7: Since the pipe is short, we will use an orifice equation for flow:

$$Q = \tfrac{1}{4}\pi d^2 \sqrt{2gH}\ C_d^{*} \qquad \text{where } C_d = .613^{*}$$

$$Q_7 = \tfrac{1}{4}\pi(2.5)^2\sqrt{64.4}\ .613\ (h+21.5)^{\frac{1}{2}}$$
$$= 24.1\ (h+21.5)^{\frac{1}{2}}$$

C_d is a function of $\frac{\text{orifice diam.}}{\text{total depth}} = f\left(\frac{2.5}{25}\right) = f(.1)$
FIG. 28 in Rouse → $C_d = .613$

* Rouse, Engineering hydraulics, p. 35

Q_8 & Q_9 : We will use underflow sluice gate equations for

8 & Q9

$$Q = \text{AREA} \sqrt{2gH} \; C_d{}^{*}$$

$C_d = f\left(\frac{\text{gate height}}{\text{depth}}\right) \doteq f\left(\frac{4.2}{25}\right) \doteq .17$

$\rightarrow C_d = .57$ (FIG. 36

$$Q_8 = 57.6 \sqrt{h+17.7}$$

$$Q_9 = 57.6 \sqrt{h+17.6}$$

from h = 0 to 1.0

$$Q_7 = 24.1 \, (h+21.5)^{\frac{1}{2}}$$

$$Q_8 = 57.6 \, (h+17.7)^{\frac{1}{2}}$$

$$Q_9 = 57.6 \, (h+17.6)^{\frac{1}{2}}$$

$$Q_1 = Q_2 = Q_3 = Q_4 = Q_5 = Q_6 = S_1 = 0$$

from h = 1.0 to 4.1

$$Q_4 = 3.3 \, (30) \, (h-1)^{3/2}$$

all others unchanged

Note that we are neglecting the affect of the arch (which starts at 3.3' & ends at 4.1') as negligible.

from h = 4.1 to 4.5

$$Q_3 = 2.8 \, (135) \, (h-4.1)^{3/2}$$

$$Q_2 = 2.8 \, (13.1)(h-4.1) \left[.5(h-4.1)\right]^{3/2}$$

all others unchanged

from h = 4.5 to 4.9

$$Q_5 = 2.8 \, (150)(h-4.5)^{3/2}$$

all others unchanged

*Rouse, Engineering Hydraulics, p. 50

<u>from h = 4.9 to 6.9</u>

$$Q_6 = 2.8(45)(h-4.9)\left[.5(h-4.9)\right]^{3/2}$$

all others unchanged

<u>from h = 6.9 to 8.3</u>

$$Q_6 = 2.8(90)(h-5.9)^{3/2}$$
$$S_1 = 2.8(10)(h-6.9)\left[.5(h-6.9)\right]^{3/2}$$

all others unchanged

from h = 8.3 up

$$Q_2 = 2.8(55)(h-6.2)^{3/2}$$
$$Q_1 = 2.8(8.7)(h-8.3)\left[.5(h-8.3)\right]^{3/2}$$

all others unchanged

PP. 5-6 is a listing of a BASIC program which calculates a Discharge-Stage Relationship.

```
LIST
100 REM: STAGE DISCHARGE PROGRAM FOR SUPPLY POND DAM, JOB 165
110 REM: ON TAPE 10, FILE 53
120 PAGE
130 PRINT "DISCHARGE FROM SUPPLY POND DAM AS A FUNCTION OF HEAD"
140 PRINT USING 150:
150 IMAGE // 2T"HEAD"30T"DISCHARGE"
160 PRINT USING 170:
170 IMAGE 1T"(FEET)"32T"(CFS)"
180 PRINT USING 190:
190 IMAGE 10T"TOTAL"5X"WASTE PIPE"5X"GATES"5X"SPILLWAY"5X"TOP OF DAM"
200 FOR H=0 TO 7 STEP 0.25
210 Q5=0
220 Q1=0
230 S1=0
240 Q2=0
250 Q3=0
260 Q6=0
270 Q4=0
280 Q7=24.1*(H+21.5)↑0.5
290 Q8=57.6*(H+17.7)↑0.5
300 Q9=57.6*(H+17.5)↑0.5
310 IF H<=1 THEN 460
320 Q4=3.3*30*(H-1)↑1.5
330 IF H<=4.1 THEN 460
340 Q3=2.8*135*(H-4.1)↑1.5
350 Q2=2.8*(13.1*(H-4.1))*(0.5*(H-4.1))↑1.5
360 IF H<=4.5 THEN 460
370 Q5=2.8*150*(H-4.5)↑1.5
380 IF H<=4.9 THEN 460
390 Q6=2.8*(45*(H-4.9))*(0.5*(H-4.9))↑1.5
400 IF H<=6.9 THEN 460
410 Q6=2.8*90*(H-5.9)↑1.5
420 S1=2.8*10*(H-6.9)*(0.5*(H-6.9))↑1.5
430 IF H<=8.3 THEN 460
```

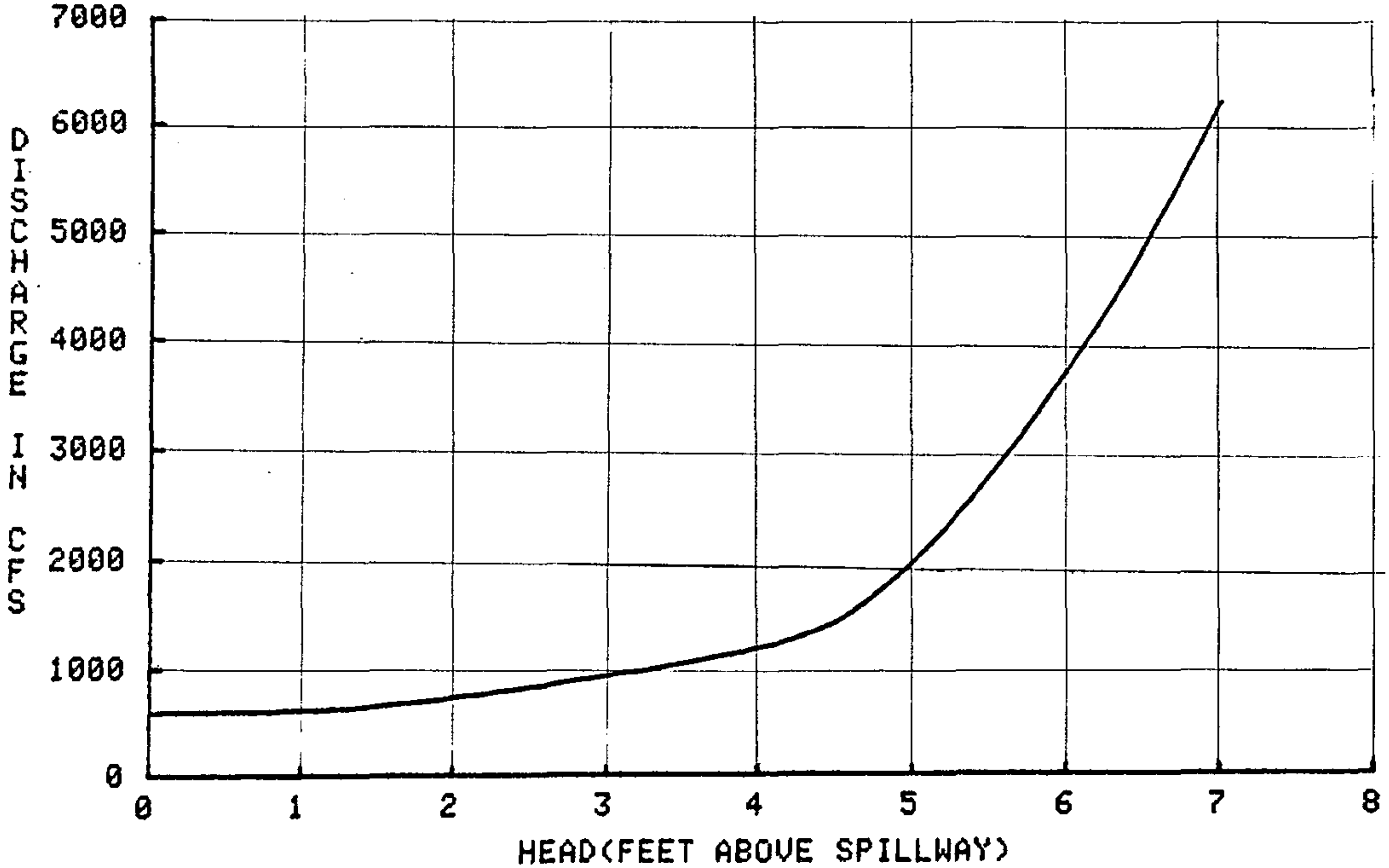

P.5

```
440 Q2=2.8*55*(H-6.2)↑1.5
450 Q1=2.8*8.73*(H-8.3)*(0.5*(H-8.3))↑1.5
460 T1=Q2+Q3+Q4+Q5+Q6+Q7+Q8+Q9+Q1+S1
470 T2=Q8+Q9
480 T3=Q2+Q3+Q5+Q6+Q1+S1
490 PRINT USING 500:H,T1,Q7,T2,Q4,T3
500 IMAGE 1T,2D.2D,8D,12D,13D,12D,13D
510 NEXT H
520 END
```

DISCHARGE FROM SUPPLY POND DAM AS A FUNCTION OF HEAD (1' Stoplogs)

HEAD (FEET)	DISCHARGE (CFS) TOTAL	WASTE PIPE	GATES	SPILLWAY	TOP OF DAM
0.00	595	112	483	0	0
0.25	599	112	487	0	0
0.50	603	113	490	0	0
0.75	607	114	493	0	0
1.00	611	114	497	0	0
1.25	627	115	500	12	0
1.50	654	116	503	35	0
1.75	687	116	507	64	0
2.00	726	117	510	99	0
2.25	769	117	513	138	0
2.50	816	118	516	182	0
2.75	868	119	520	229	0
3.00	922	119	523	280	0
3.25	980	120	526	334	0
3.50	1041	121	529	391	0
3.75	1105	121	532	451	0
4.00	1172	122	535	514 792	0
4.25	1263	122	538	580 867	22
4.50	1410	123	542	648 945	97
4.75	1642	123	545	719 1025	255
5.00	1945	124	548	792 [illegible]	481
5.25	2303	125	551	867	761
5.50	2713	125	554	945	1089
5.75	3171	126	557	1025	1463
6.00	3675	126	560	1107	1883
6.25	4227	127	563	1191	2346
6.50	4823	128	566	1277	2853
6.75	5465	128	568	1365	3404
7.00	6158	129	571	1455	4003

STAGE-DISCHARGE CURVE AT SUPPLY POND DAM (1' stoplogs)



DAM FAILURE ANALYSIS:

Peak Outflow at failure = Normal outflow at failure elevation + Outflow through breach

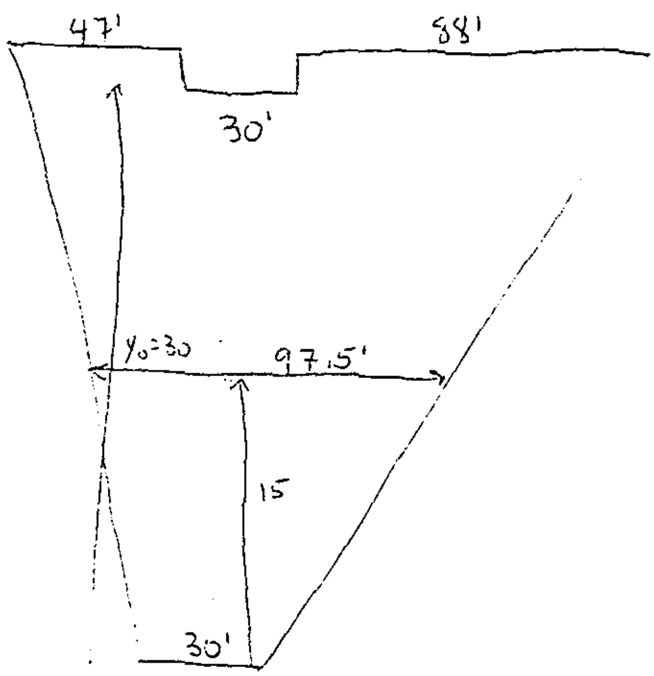
Assume that the dam fails when the embankment is overtopped, at elevation 140.9 (h = 4.1').

The normal outflow at this elevation is 1200 cfs

Breach outflow,

$$Q_{p_1} = \frac{8}{27} W_b \sqrt{g} \; Y_0^{3/2}$$

Where W_b = width of breach ≤ .4 (Dam width at 50% of Y_0) = .4 (97.5) ≅ 39'



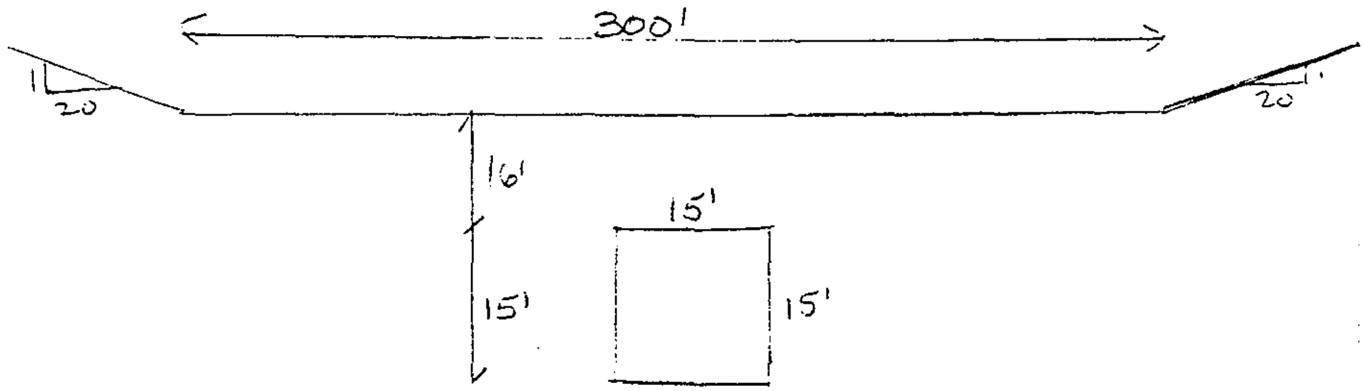
Y_0 = height above streambed ≅ 30'

$$Q_{p_1} = \frac{8}{27} \sqrt{g} (39)(30)^{3/2} = 10{,}800 \text{ cfs}$$

Q_{TOT} = 10,800 + 1200 = 12000 cfs

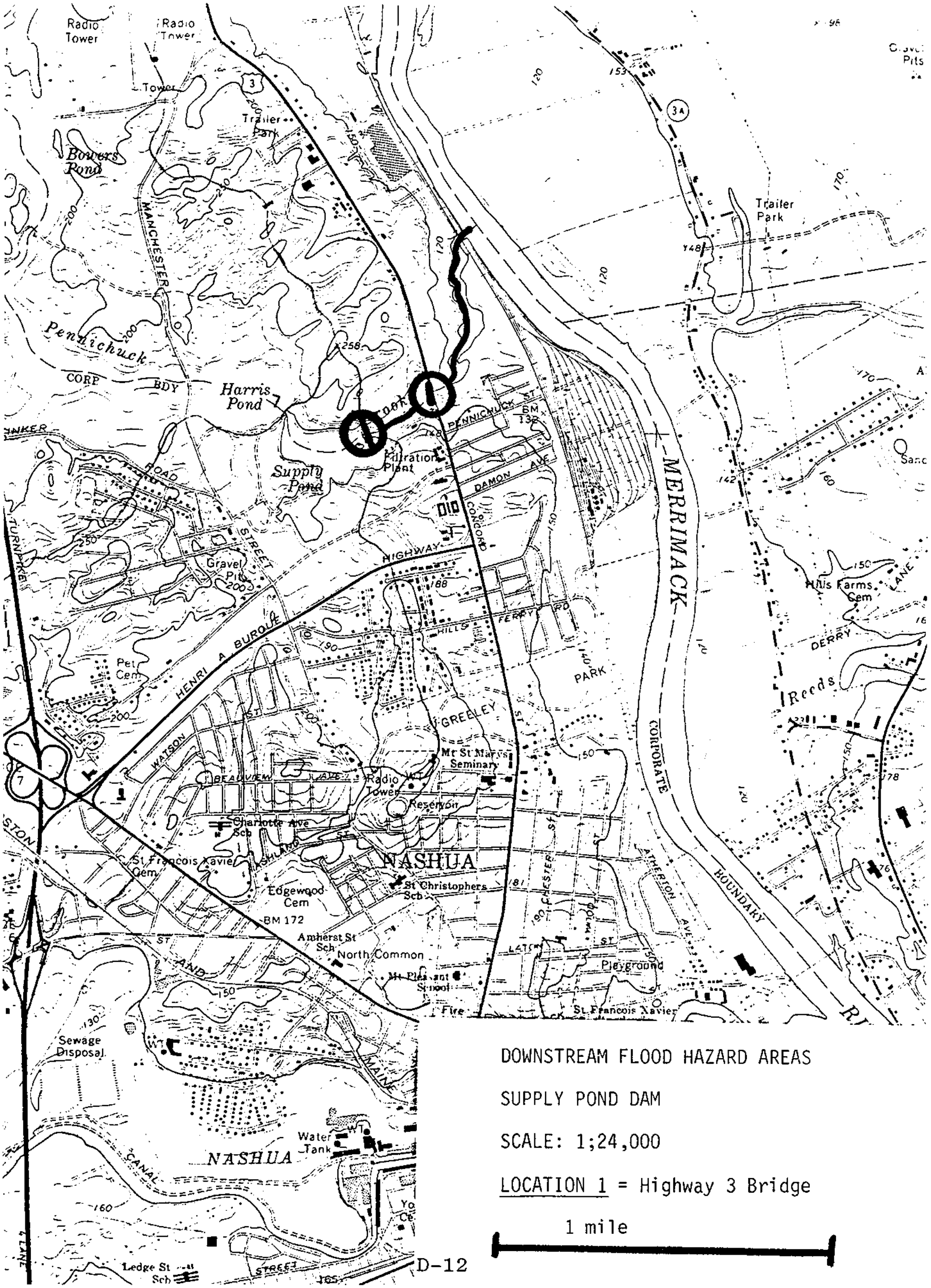
There are two downstream structures which would be affected by the dam failure flood wave. The pump stations and piping immediately below the dam would suffer heavy damage. The potential for loss of life at these structures is low.

The second structure affected is the Highway 3 bridge about 2000' downstream of the dam (see map, p. 11 for locations). There is no significant storage in the channel upstream of the bridge, so the peak flow of 12,000 cfs would reach the bridge unattenuated. The cross section at the bridge (from Anco FIS cross sections) is:



Not to scale

The BASIC program shown on p. 12 calculates Discharge versus stage for the cross section at the bridge. The Culvert flows are from an extrapolation of Chart 1 (Box Culverts with inlet control) of HYDRAULIC ENGINEERING CIRCULAR 5, FHWA.



DOWNSTREAM FLOOD HAZARD AREAS

SUPPLY POND DAM

SCALE: 1;24,000

<u>LOCATION 1</u> = Highway 3 Bridge

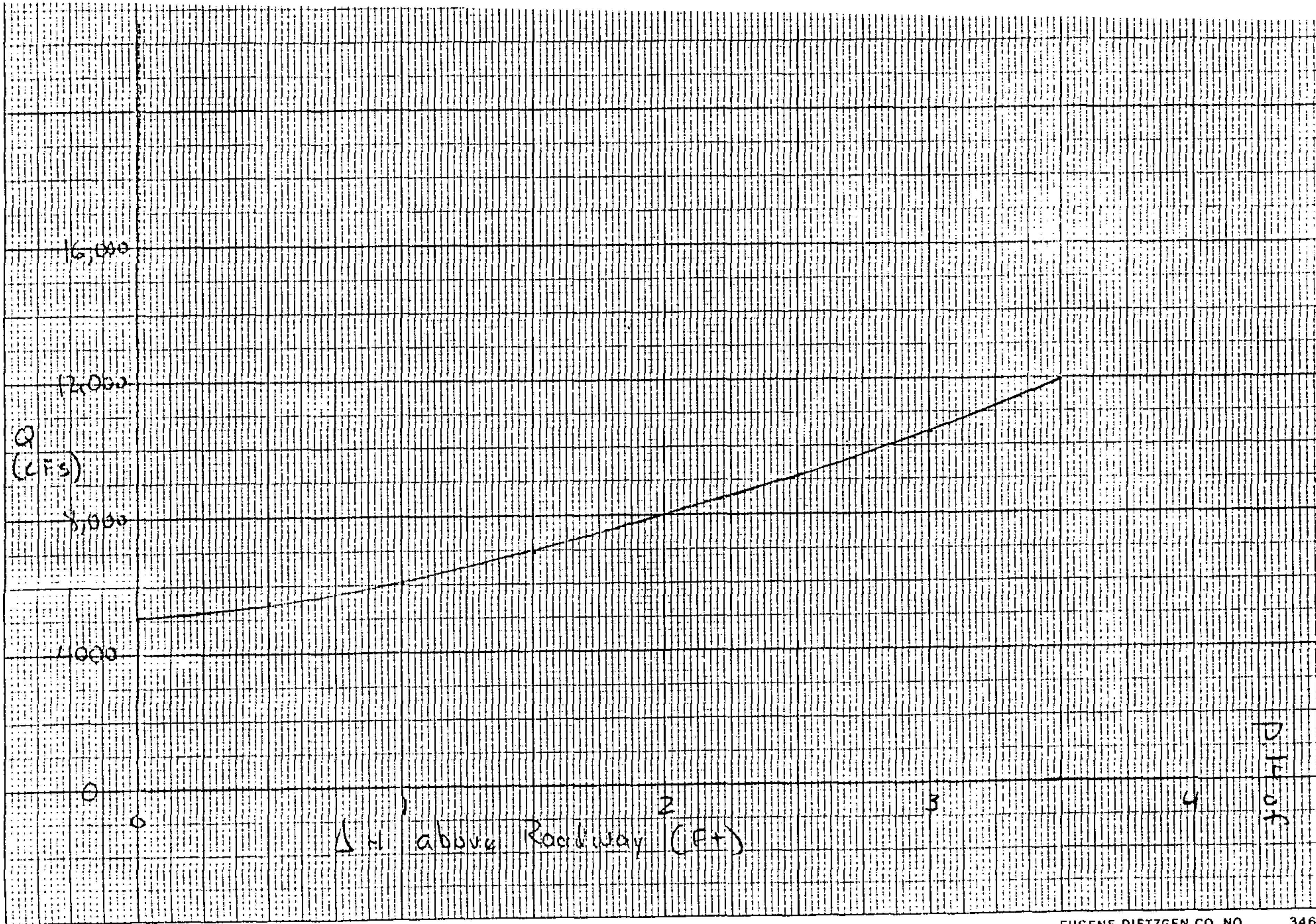
1 mile

```
LIST
100 REM: STAGE-DISCHARGE RELATIONSHIP FOR HIGHWAY 3 BRIDGE
110 REM:                     SUPPLY POND DAM
120 REM:                     TAPE 10, FILE 50
130 PAGE
140 PRINT "DISCHARGE OVER HIGHWAY 3 BRIDGE AS A FUNCTION OF HEAD"
150 PRINT USING 160:
160 IMAGE // 2T"HEAD"30T"DISCHARGE"
170 PRINT USING 180:
180 IMAGE 1T"(FEET)"32T"(CFS)"
190 PRINT USING 200:
200 IMAGE 10T"     TOTAL          CULVERT                 TOP OF ROAD"
210 PRINT " "
220 FOR H=0 TO 5 STEP 0.5
230 READ Q1
240 Q2=2.8*300*H↑1.5
250 Q3=2*2.8*20*H*(0.5*H)↑1.5
260 Q4=Q2+Q3
270 Q5=Q4+Q1
280 PRINT USING 290:H,Q5,Q1,Q4
290 IMAGE 2T,2D.1D,14D,16D,19D
300 NEXT H
310 DATA 5100,5160,5220,5280,5340,5400,5460,5520,5580,5640,5700
```

P.12 of

DISCHARGE OVER HIGHWAY 3 BRIDGE AS A FUNCTION OF HEAD

HEAD (FEET)	DISCHARGE (CFS) TOTAL	CULVERT	TOP OF ROAD
0.0	5100	5100	0
0.5	5464	5160	304
1.0	6100	5220	880
1.5	6932	5280	1652
2.0	7940	5340	2600
2.5	9112	5400	3712
3.0	10442	5460	4982
3.5	11928	5520	6408
4.0	13567	5580	7987
4.5	15360	5640	9720
5.0	17305	5700	11605


16,000
12,000
8,000
4000
0
Q
(cfs)
0
1
2
3
4
ΔH above Roadway (ft)

The flow of 12,000 cfs would overtop the roadway
by about 3.5', and would probably cause significant
structural damage to the bridge. Also, due to the rapid
rate of rise expected, there is some potential for loss of
life.

There is one structure along the stream between
Supply Pond Dam and the Highway 3 Bridge, a Pennichuck
Water Works Sewage Treatment Plant. The lowest
part of the plant is 29' above the stream bed, and so
would be above the Dam Failure Flood Wave. Pennichuck
Brook widens out quickly below Highway 3, and the flood
wave would be attenuated significantly before it reached the
Merrimack River some 3000' downstream of Highway
3.

Test Flood Analysis:

Size Classification = Small

Hazard Classification = Significant

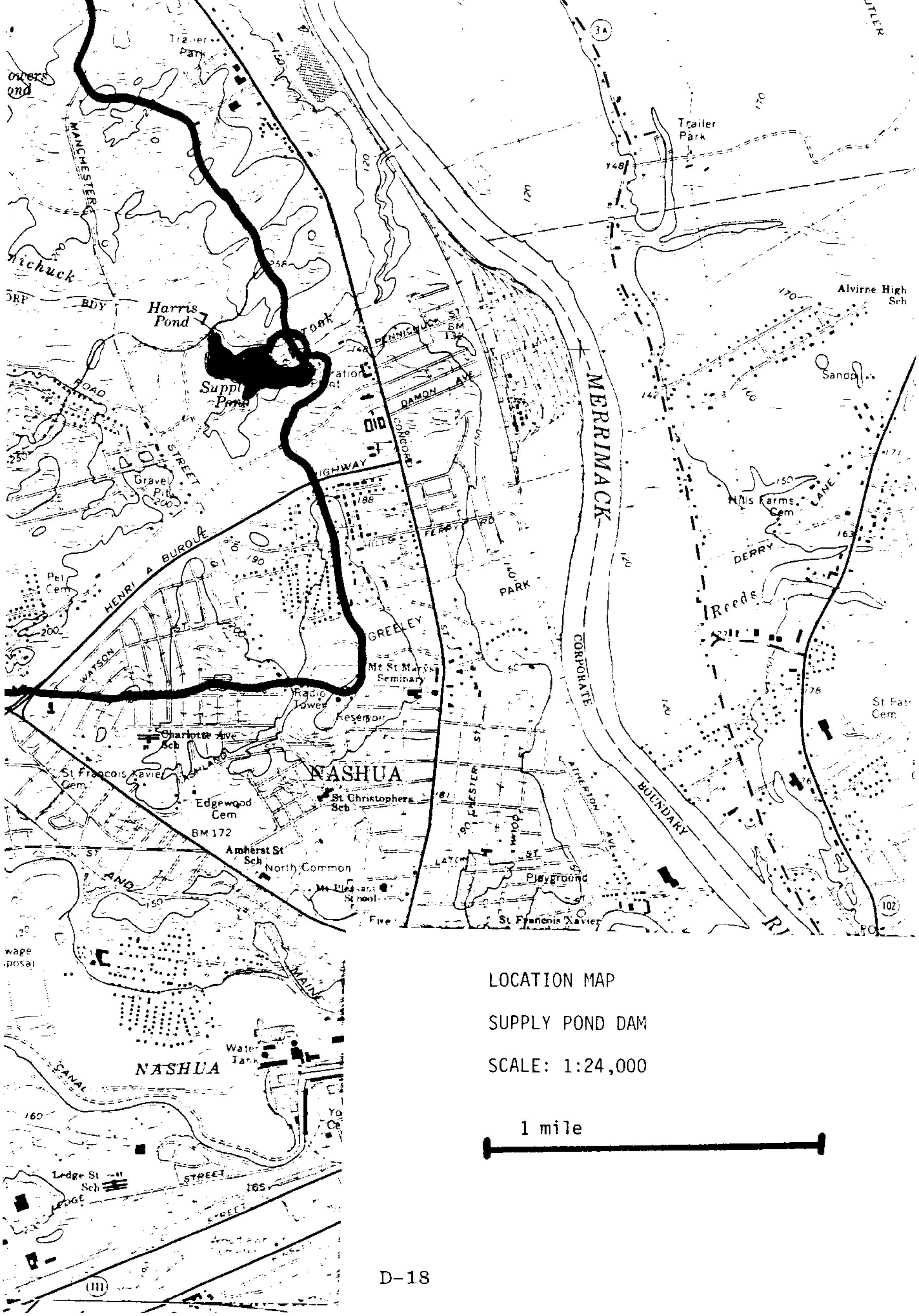
The hazard classification is based on the potential for damage to the pump station and conduits downstream of the dam and the Highway 3 bridge in the event of dam failure.

Test Flood: 100 yr. to ½ PMF

The FIS work by ANCO produces very low values of inflow to Supply Pond, with the 100 year flow of 440 cfs equal to only 17.3 csm. The reason for these low flows is the character of the basin upstream of Supply Pond Dam. The basin is swampy, with three large ponds (Bowers, Holt's and Harris) upstream.

However, it is apparent from ANCO's work that the primary control causing low flow is the culvert across Pennichuck Brook at Route 101 A. The culvert controls 19 sq. mi. of the drainage area, and drastically reduces peak flows.

For the purposes of this Test Flood Analysis it does not seem proper to allow a potentially temporary structure such as the Route 101 A culvert - which might be enlarged or removed at any time - to determine Test



LOCATION MAP

SUPPLY POND DAM

SCALE: 1:24,000

1 mile

Flood inflows. Therefores, ANCO's FIS flow values would not apply to this study.

Since the hazard for this dam is on the low side of significant, the 100 year inflow is the appropriate test flood. The March, 1936 storm is generally accepted as approximating the 100 year storm for New England. Although the flows for Pennichuck Brook are not available, the 1936 flood produced flows of around 100 csm for drainage areas similar in size and character to the Pennichuck.

Peak inflow = 25.4 sq. mi (100 csm) = 2540 cfs

The Storage-Elevation curve for Supply Pond is on p. 19. The curve assumes that the pond has a surface area of 20 acres, and does not spread as it rises.

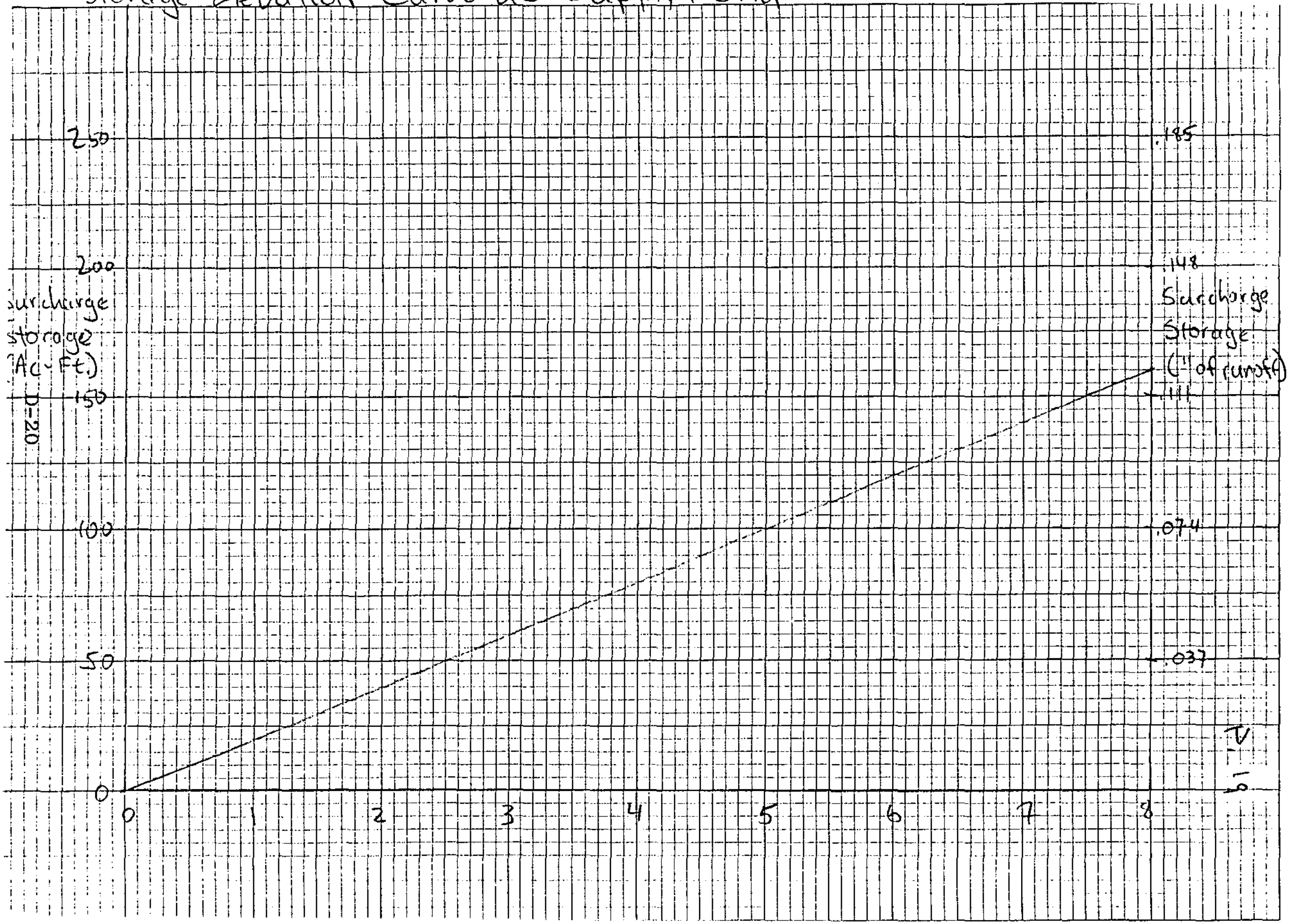
$$1'' \text{ of runoff} = 1''\left(\frac{1'}{12''}\right)\left(640 \frac{Ac}{sq\,mi}\right)(25.4\ sq\ mi)$$
$$= 1355\ ac\text{-}ft \text{ of storage}$$

$\rightarrow$ 1 Ac-ft = .00074" of runoff

$\rightarrow$ 1 ft of rise = 20 (.00074) = .0148" of runoff.

P. 20 gives a graphical routing of the test flood inflow through Supply Pond.

Storage-Elevation Curve at Supply



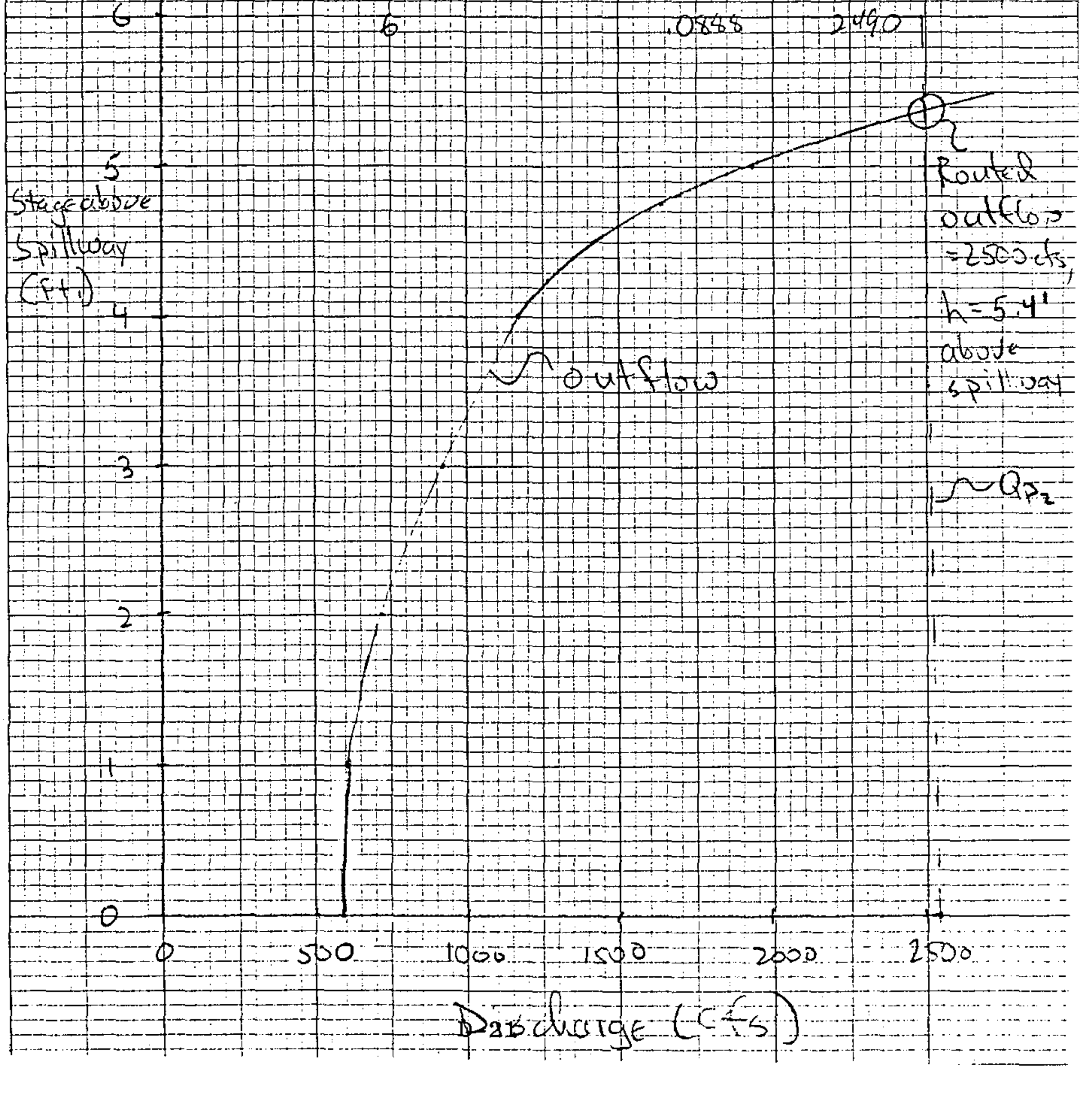
D-20

165 Dam Safety Supply Pond Dam, #7 TCG, 3-26-71, p. 20

100 yr. Flood → 2540 cfs = 19"/4 = 4.75" runoff

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{Stor}{4.75}\right) = 2540\left(1 - \frac{Stor}{4.75}\right)$$

Head above spillway (ft)	Stor	Q_{p_2} (cfs)
0	0	2540
7	.1036	2480
6	.0888	2490



The peak discharge after accounting for storage in Supply Pond is 2500 cfs, with the peak water surface elevation 5.4' above the spillway crest at elevation 142.2 ft. MSL. This is 1.3 ft above the top of dam.

If the stop logs were removed, the peak elevation would still be about 5.7' above the spillway crest (elevation 143.0, 1.1 ft. above the top of dam.)

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
NH	125	NED	NH	011	02				SUPPLY POND DAM	4247.5	7128.5	21FEB79

POPULAR NAME	NAME OF IMPOUNDMENT
	SUPPLY POND

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	05	PENNICHUCK BROOK	NASHUA	5	70000

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
PGREGR	1870	S	28	28	245	171	NED	N	N	N	N	21FEB79

REMARKS
1-NH16506 21-STONE MASONRY 22-ESTIMATE

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
2	550	C	30	514												

OWNER	ENGINEERING BY	CONSTRUCTION BY
PENNICHUCK WATER WORKS		

REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
GOLDBERG ZOINO DUNNICLIFF ASSOC	31OCT78	PUBLIC LAW 92-367

REMARKS